

Historic, Archive Document

Do not assume content reflects current scientific knowledge, policies, or practices.



Agriculture

Forest Service

Forest
Products
Laboratory

Dividends From Wood Research

Recent Publications

January-June 1988

explanation and instructions

"Dividends From Wood Research" is a semiannual listing of recent publications resulting from wood utilization research at the Forest Products Laboratory (FPL). These publications are produced to encourage and facilitate application of Forest Service research. This issue lists publications received from the printer by the FPL Publications Section between January 1, 1988, and June 30, 1988.

Each publication listed in this brochure is available through at least one of the sources below. For each entry in the brochure, we indicate the primary source for that publication and show you how to obtain a copy:

Available from FPL (indicated by an order number before the title of the publication): Quantities limited. Circle the order number on the blank at the end of the brochure and mail the blank to FPL.

Available through sales outlets (indicated by the name of the outlet and, when available, price information): Major sales outlets are the Superintendent of Documents, the National Technical Information Service (NTIS), and various private publishers. Order directly from the outlet.

Available through libraries: Research publications are available through many public and university libraries in the United States and elsewhere. U.S. Government publications are also available through many Government Depository Libraries. Check with a major library near you to determine availability.

list of categories

Publications are listed in this brochure within the following general categories:

- Anatomy and identification
- Biodeterioration and protection
- Chemicals from wood
- Energy
- Engineering properties and design criteria
- Fire safety
- General
- Microbial and biochemical technology
- Mycology
- Processing of wood products
- Pulp, paper, and packaging
- Structural fiber and particle products
- Timber requirements and economics
- Tropical wood utilization
- Wood bonding systems

PSW FOREST AND RANGE
EXPERIMENT STATION

OCT 14 1988

STATION LIBRARY COPY

anatomy and identification

1. Creation of a Large Database With IAWA Standard List Characters

Miller, R. B.; Pearson, R. G.; Wheeler, E. A.
IAWA Bull. 8(3): 219-232; 1987.

This paper is intended to contribute to the discussion leading to a revised IAWA Standard list of characters suitable for computer-assisted wood identification.

biodeterioration and protection

2. Approaches to the Improvement of Biological Resistance of Wood Through Controlled Release Technology

Chen, George C.; Rowell, Roger M.
Am. Paint Coatings J. 72(16): 37-41; October 12, 1987.

Controlled release is a new technology that minimizes the environmental and health hazards of treating wood with preservatives. This technology, if it were fully developed, could be used to release wood preservatives in an effective low dose, leaving no free chemicals to leach into the environment. This paper discusses current work in wood protection relating to controlled release technology.

3. Comparisons of Pentachlorophenol Formulations in Soil-Block Tests

DeGroot, Rodney C.
Wood Fiber Sci. 20(2): 209-214; 1988.

This study was conducted to determine if threshold levels for pentachlorophenol would be comparable for *Conio-phora puteana* and for *Gloeophyllum trabeum* with each formulation, and whether the different pentachlorophenol formulations were equally effective in preventing brown rot in soil block tests.

4. Role of Pigment Concentration in the Weathering of Semitransparent Stains

Feist, William C.
Forest Prod. J. 38(2): 41-44; 1988.

This paper describes the weathering performance of semitransparent stains on smooth wood surfaces, and the relationships among pigment concentration, water repellent, and wood weathering.

5. Weathering Performance of Finished Southern Pine Plywood Siding

Feist, William C.
Forest Prod. J. 38(3): 22-28; 1988.

The primary objective of the study was to develop a better understanding of the weathering performance of finished Southern Pine (*Pinus sp.*) plywood. The finishes included in this study represented commercial and laboratory preparations. The effects of pretreatment, primer, finish, and substrate interactions at three outdoor exposure sites in the United States are described.

6. Effect of Carbohydrate and Nitrogen on Hydrogen Peroxide Formation by Wood Decay Fungi in Solid Medium

Highley, Terry L.
FEMS Microbiology Letters 48: 373-377; 1987.

Hydrogen peroxide has been implicated in degradation of wood by both brown-rot and white-rot fungi. This study found that low concentrations of nitrogen and carbohydrates (cellobiose, glucose, xylose, and mannose) in an agar medium had little effect on hydrogen peroxide production by white-rot fungi. However, low concentrations of nitrogen and carbohydrates stimulated hydrogen peroxide production by brown-rot fungi. Use of the chromogen 2,2'-azino-di(3-ethyl benzthiazoline-6-sulphonic acid) (ABTS) with horseradish peroxidase to detect hydrogen peroxide by the fungi was slightly better than detection by the chromogen o-dianisidine with horseradish peroxidase. An auxiliary test to check the role of hydrogen peroxide in wood decay found that hydrogen peroxide-negative isolates of the white-rot fungi *Phanerochaete chrysosporium* and *Ganoderma applanatum* were unable to decay sweetgum and Southern Pine.

7. Longevity of Chloropicrin and Vapam in Controlling Internal Decay in Creosoted Douglas-fir Timbers Above Ground

Highley, Terry L.
Mater. Org. 22(3): 225-233; 1987.

The persistence, movement, and effectiveness of chloropicrin and Vapam (sodium N-methyl dithiocarbamate) in large, horizontal Douglas-fir timbers were evaluated 7 years after fumigation. Chloropicrin prevented reestablishment of decay fungi; reinvasion occurred in some Vapam-treated timbers. Residual fungistatic effect was detected up to 1.2 m from the fumigation site in chloropicrin-treated timbers but not in Vapam-treated timbers.

8. Statistical Determination of Preservative Threshold Retention in Soil Block Tests

Link, Carol L.; DeGroot, Rodney C.
Wood Fiber Sci. 19(4): 392-406; 1987.

This statistical approach allows estimation of the threshold retention value for preservatives assayed in soil block tests. The threshold value corresponds to 1 percent (or

any other positive value) weight loss from decay only. An associated confidence interval can be given for this threshold estimate, allowing comparison of different preservatives. An "operational" weight loss line is used to adjust the percent weight loss data for loss caused by preservative or solvent evaporation. The adjusted data are then fitted by an exponential or logistic model. Statistical tests for lack of fit are used to test model assumptions. Plots are used to visually judge fitted curves and the estimated threshold preservative retention.

9. Biological Resistance of Southern Pine and Aspen Flakeboards Made From Acetylated Flakes

Rowell, Roger M.; Esenther, Glenn R.; Nicholas, Darrel D.; Nilsson, Thomas
J. Wood Chem. Technol. 7(3): 427-440; 1987.

The purpose of this research was twofold: (1) to determine if standard soil block, fungal cellar, and termite tests could be applied directly to flakeboards containing phenol-formaldehyde or if specimens must first be leached to remove any toxic adhesive components and (2) to use these test methods to determine the resistance of flakeboards made from dip-acetylated flakes to brown-, white-, and soft-rot fungi, tunneling bacteria, and subterranean termites.

10. Strength Tests on Acetylated Aspen Flakeboards Exposed to a Brown-Rot Fungus

Rowell, Roger M.; Youngquist, John A.;
Imamura, Yuji
Wood Fiber Sci. 20(2): 266-271; 1988.

Aspen flakeboards made from control flakes and acetylated flakes at 18 percent acetyl weight gain using phenol-formaldehyde or isocyanate adhesives were subjected to a bending creep test under progressive brown-rot fungal attack with *Tyromyces palustris*. Deflection of the boards was measured as a function of time until failure. Isocyanate-bonded control flakeboards failed in an average of 26 days, while isocyanate-bonded acetylated boards showed little deflection after 100 days in test. Average weight loss of isocyanate-bonded control boards at failure averaged 6.2 percent, while the acetylated boards showed about 1.0 percent weight loss at the end of 100 days. Phenol-formaldehyde-bonded control flakeboards failed in an average of 76 days, while acetylated boards showed little deflection after 100 days in test. Average weight loss of phenol-formaldehyde-bonded control boards at failure averaged 8.6 percent, while the acetylated boards showed no weight loss after 100 days.

11. Dimensional Stability and Resistance to Biological Degradation of Wood Products by a Simplified Acetylation Procedure

Tillman, Anne-Marie; Simonson, Rune; Rowell, Roger M.
In: Proceedings, 4th International symposium of wood and pulping chemistry; 1987 April 27-30; Paris,

France. Paris: Wood and Pulping Chemistry Association; 1987: 125-129.

A procedure for acetylation of wood with acetic anhydride, without catalyst or organic cosolvent, was developed. The procedure shortens the reaction time and simplifies the recovery of chemicals. The procedure could be applied to solid wood as well as to wood particles for particleboard production. Both hardwoods and softwoods could be acetylated. Dimensional stability of both solid wood and particleboards was greatly improved by acetylation. The resistance to biological degradation was greatly improved as shown by fungus cellar tests. It was shown that the consumption of acetic anhydride could be calculated stoichiometrically based on the degree of acetylation and on the moisture content of the wood.

12. Effect of Dilute Acid on the Accelerated Weathering of Wood

Williams, R. Sam

JAPCA 38(2): 148-151; 1988.

Reported are results of a detailed study that included sulfuric, nitric, and sulfuric acid treatment of wood over a pH range of 2.0 to 4.0 and chemical analysis of the degradation products isolated from the sulfuric and sulfuric acid solutions. In addition, a new gravimetric procedure was developed for assessing erosion during accelerated weathering.

chemicals from wood

13. Condensed Tannins. Base-Catalysed Reactions of Polymeric Procyanidins with Phloroglucinol: Intramolecular Rearrangements

Laks, Peter E.; Hemingway, Richard W.; Conner, Anthony H.

J. Chem. Soc. Perkin Trans. I; 1987: 1875-1881.

Condensed tannin preparations obtained by alkaline extraction of conifer barks are known to exhibit lower reactivity with aldehydes and increased acidity compared to polymeric procyanidins obtained from plants by neutral-solvent extraction. In an effort to explain these differences, Sears et al. refluxed (+)-catechin in aqueous sodium hydroxide and obtained two rearrangement products, catechinic acid and isocatechinic acid. Catechinic acid was shown to be an enolic form of 6-(3,4-dihydroxyphenyl)-7-hydroxybicyclo[3.3.1]-nonane-2,4,9-trione by X-ray crystallography of its trimethyl ether. Similar structures were proposed for the reaction products of condensed tannins in alkaline solution since many of their properties were consistent with the structure of catechinic acid. However, no products have been isolated from the reaction of condensed tannins in alkaline solutions to support this hypothesis. The base-catalysed reactions of polymeric procyanidins were examined because many of their industrial applications involve their dissolution or reaction at alkaline pH.

energy

14. Mineral Matter in Coal and Wood: Implications for Solid Fueled Gas Turbines

Ragland, Kenneth W.; Baker, Andrew J.

In: Combustion fundamentals and applications: 1987 spring technical meeting of the central states section of The Combustion Institute; 1987 May 11-12; Argonne, IL. Argonne, IL: Argonne National Laboratory; 1987: 117-122.

The results of this paper indicate that wood is a good turbine fuel because the mineral matter is disseminated in sizes less than 1 μm . Coals with low amounts of adventitious ash, and little pyrite (which tends to be distributed in the larger sizes) and quartz (which is particularly abrasive) should be designated for use in gas turbines. Combustion zone temperatures should not greatly exceed turbine inlet temperatures to minimize agglomeration of ash particles.

A Model of Chunkwood Combustion

Ragland, Kenneth W.; Boerger, James C.; Baker, Andrew J.

Forest Prod. J. 38(2): 27-32; 1988.

Available from Kenneth W. Ragland, Room 127, Engineering Research, University of Wisconsin, Madison, WI 53706. No charge.

This paper summarizes the results of experimental observations of the combustion of individual chunkwood-sized wood fuel in a spreader stoker boiler and also describes the development of a time-temperature model for the heat transfer into burning chunkwood. A combustion model that predicts the observed combustion rate and total combustion time of chunkwood was also developed. It is essential to know the combustion rate and total burn time of chunkwood-sized wood fuel to plan for fuel feed rates and adjustments in operating conditions.

15. LOGHEAT: A Computer Program for Determining Log Heating Times for Frozen and Nonfrozen Logs

Steinhagen, H. Peter; Lee, Harry W.; Loehnertz, Stephen P.

Forest Prod. J. 37(11/12): 60-64; 1987.

LOGHEAT is a computer program that calculates log heating times for frozen and nonfrozen logs and log energy consumption. This information is needed in mills that process logs into veneer, plywood, and waferboard, particularly in cold climate zones. The program is simple to use and gives good results in the case of one-dimensional heat transfer (log length greater than four diameters) with water or condensing steam as the heating medium. It is more practical than previous methods in providing reliable estimates of log heating and thawing time and energy consumption.

16. Effect of Lignin Content and Extractives on the Higher Heating Value of Wood

White, Robert H.

Wood Fiber Sci. 19(4): 446-452; 1987.

As part of a study of the charring rate of wood, the higher heating values (gross heat of combustion) and the chemical composition of samples from four hardwoods and four softwoods were determined. The higher heating value of wood was correlated with lignin and extractive contents. There was a highly significant linear correlation between the higher heating value of the extractive-free wood and lignin content. Equations are presented that can be used to determine the higher heating value of extractive-free wood when the Klason lignin content is known. The equations should be useful to those interested in using a variety of species of wood as fuel.

17. Investigation of Fundamentals of Two-Stage, Dilute Sulfuric Acid Hydrolysis of Wood

Zerbe, John I.; Baker, Andrew J.

In: Klass, Donald, ed. Energy from biomass and wastes X. Chicago: Institute of Gas Technology; 1987: 927-947.

A fundamental analysis of production of ethanol from southern red oak (*Quercus falcata*) resulted in recommendations for a process that is technically ready for commercial exploitation, but some equipment testing and evaluation are necessary first. Such evaluation was the objective of this paper.

engineering properties and design criteria

18. Roof Connections in Houses: Key to Wind Resistance

Conner, Harold W.; Gromala, David S.; Burgess, Donald W.

J. Struct. Eng. 113(12): 2459-2474; 1987.

This study relates the strength of roof connections to the loads imposed by extreme winds. It begins by discussing the myths and realities of severe storms, especially tornadoes. It then discusses methods of measuring wind speeds and the effect of wind on structures. Finally, the paper shows how improved connections can help a house withstand the majority of tornadic winds.

19. Effect of Grade on Load Duration of Douglas-Fir Lumber in Bending

Gerhards, C. C.

Wood Fiber Sci. 20(1): 146-161; 1988.

Select Structural, No. 2, and No. 3 Douglas Fir 2 by 4 specimens were tested in bending at several rates of loading and several levels of constant load to determine the effect of grade on load duration. The constant load results suggest that lower grades of lumber have shorter times to failure; however, differences in the load duration effect between lumber grades may not be statistically significant.

These results also suggest that allowable bending properties of lumber may be nonconservative for any design load that really exists for the design duration. Recommended load duration design factors based on traditional methods of derivation are included along with discussion of stress level threshold and absolute stress effect. This paper should be useful to engineers responsible for wood structural design and to grading agencies for evaluating the safety of recommended allowable lumber properties, from the standpoint of both real loads and their durations as well as code loads.

20. Effect of High-Temperature Drying on Bending Strength and Load Duration of Douglas-Fir 2 by 4's

Gerhards, C. C.

Forest Prod. J. 38(4): 66-72; 1988.

The objective of this study was to evaluate the high-temperature drying (HTD) effects on static strength and load duration of Douglas-fir lumber, a species known to be affected by HTD. This study is limited in scope to compare HTD to conventional drying; the sample size and load durations are not large enough to establish new duration-of-load factors.

21. Predicting the Effect of Moisture Content on the Flexural Properties of Douglas-Fir Dimension Lumber

Green, David W.; Evans, James W.; Barrett, J. David; Aplin, E. Nicholas

Wood Fiber Sci. 20(1): 107-131; 1988.

Current procedures for adjusting estimates of the mechanical properties of lumber for changes in moisture content are based on trends in the observed means. This study was initiated to develop analytical procedures for adjusting estimates of the flexural properties of 2-in-thick Douglas-fir dimension lumber that would be applicable to all levels of the flexural properties. Equations are derived for adjusting modulus of rupture, modulus of elasticity, moment capacity, and flexural stiffness for changes in moisture content. The best of these equations are found to be significantly more accurate than current procedures for adjusting estimates of strength properties.

22. Butt Joint Reinforcement in Parallel-Laminated Veneer (PLV) Lumber

Larson, D. S.; Sandberg, L. B.; Laufenberg, T. L.; Krueger, G. P.; Rowlands, R. E.

Wood Fiber Sci. 19(4): 414-429; 1987.

The objective of this research was to develop the technology for sizing and placement of high-strength reinforcements of butt-jointed veneers in laminated veneer lumber. Finite-element methods, as used to analyze the reinforced butt joints, provided the input on which the design parameters were based. Experimental results of a single joint design allowed a comparison to analytically predicted strain levels.

23. Creep Testing of Structural Composite Panels: A Literature Review and Proposed Standard

Laufenberg, Theodore L.

In: Maloney, Thomas M., ed. Proceedings, 21st International particleboard/composite materials symposium; 1987 March 24-26; Pullman, WA. Pullman, WA: Washington State University; 1987: 297-313.

This paper reviews the world literature on creep-testing methods, results, and analyses for structural composite panels. Establishing the need for a test standard with this literature review, a proposal is made for the creation of a standard method of testing and reporting creep information. Use of this standard by other researchers will provide the opportunity for a consistently derived data base on creep behavior of panel products.

24. Estimation and Confidence Intervals for Parameters of a Cumulative Damage Model

Link, Carol L.; Gerhards, Charles, C.; Murphy, Joseph F.

USDA Forest Serv. Res. Pap. FPL-RP-484; 1988. 10 p.

An exponential cumulative damage model has been proposed for the duration-of-load phenomenon in lumber. The amount of damage depends upon the load history and the underlying inherent strength. Experimental load histories include ramp loading and constant loading after a period of ramp loading. The underlying inherent strength by a lognormal or Weibull distribution is modeled. The parameters are then estimated using iterative reweighted nonlinear least squares. A heuristic argument is used to derive variances that are shown to be approximate through simulation.

25. Modeling the Effect of Moisture Content on the Flexural Properties of Dimension Lumber

Link, Carol L.

In: Current topics in forest research: emphasis on contributions by women scientists: Proceedings of a national symposium; 1986 November 4-6; Gainesville, FL. Gen. Tech. Rep. SE-46. Asheville, NC: U.S. Department of Agriculture, Forest Service: 96-104.

This paper discusses modeling the effect of moisture content on flexural properties of Southern Pine and how to judge the adequacy of a model. Traditional models were inappropriate for strength properties.

26. Sensitivity of Truss Plate Model Parameters to Parameter Determination Methods

McCarthy, Monica; Little, James K.
Forest Prod. J. 38(5): 63-67; 1988.

The objective of this study was to determine the sensitivity of Foschi's parameter values to different parameter determination methods and to make recommendations

aimed toward a standardized parameter determination method.

27. A System Approach to Structural Design on Roof Assemblies

McCarthy, Monica; Wolfe, Ronald

In: Current topics in forest research: emphasis on contributions by women scientists: Proceedings of a national symposium, 1986 November 4-6; Gainesville, FL. Gen. Tech. Rep. SE-46. Asheville, NC: U.S. Department of Agriculture, Forest Service: 89-91.

Current design procedures for light-frame residential roof assemblies do not encourage the most efficient or innovative use of material. These procedures are based on properties of each individual member without concern for interactions between members. At the Forest Products Laboratory we are developing analytical structural models that will eventually lead to system-oriented design. We tested four full-scale roof assemblies to failure to verify these roof assembly models. These structural models will be useful to those involved in developing design recommendations. The models will help evaluate the effects of factors such as lumber strength and stiffness, roof pitch, truss configuration, span, sheathing properties, and connector properties on roof assembly performance. Significant improvements in material utilization could result from design changes based on this sensitivity analysis.

28. Damage Accumulation in Wood Structural Members Under Stochastic Live Loads

Murphy, J.; Ellingwood, B.; Hendrickson, E.
Wood Fiber Sci. 19(4): 453-463; 1987.

Damage accumulation in wood structural members was assessed using realistic stochastic modeling of live load. The model indicates that practically all damage occurs when the live load intensity is equal or nearly equal to the nominal live load, a quantity required by codes for design. Currently, basic allowable stresses for wood are calculated assuming a period of 10 years spent at the nominal live load. The model indicates that the time the live load is at or above the nominal is not 10 years but about 40 days in a reference period of 50 years. This strongly suggests that the 10-year period generally assumed for setting allowable stresses is much too long.

29. Development and Use of Stress Laminated Timber Deck Bridges

Oliva, Michael G.; Dimakis, Al G.; Ritter, Michael
In: Tall, Lambert, ed. Bridges and transmission line structures: Proceedings of the sessions at Structures Congress '87 related to bridges and transmission line structures; 1987 August 17-20; Hyatt Orlando Hotel, Orlando, Florida. Sponsored by the Structural Division of the American Society of Civil Engineers.

This presentation provides a brief overview of the concepts, development, research needs, economics, and recent use of stress-laminated timber bridge decks. The desirable qualities and drawbacks of stress-lam decks are discussed in relation to bridge needs. The available design

approaches are mentioned with current research aimed at improving design techniques. Recent bridges in the United States using stress-lam decks and their construction procedures are described and illustrated.

30. Strength of Mechanically Fastened Wood Connections

Patton-Mallory, Marcia

In: Current topics in forest research: emphasis on contributions by women scientists: Proceedings of a national symposium; 1986 November 4-6; Gainesville, FL. Gen. Tech. Rep. SE-46. Asheville, NC: U.S. Department of Agriculture, Forest Service: 92-95.

The results of this research are used as a basis for wood connection design criteria, published by the National Forest Products Association, which are subsequently incorporated in the Uniform Building Code and local building codes.

31. Shear Design of Wood Beams: State of the Art

Soltis, Lawrence A.; Gerhardt, Terry D.
USDA Forest Serv. Gen. Tech. Rep. FPL-GTR-56; 1988. 9 p.

Current shear design technology in the United States for lumber or glued-laminated beams is confusing. This report summarizes shear stress and strength research including both analytical and experimental approaches. Both checked and uncheck beams are included. The analytical work has been experimentally verified for only limited load conditions and span-to-depth ratios. Future research is required to better define the effects of beam size, load configuration, checks, and combined stresses on shear design.

32. Timber Bolted Connection Design

Soltis, Lawrence A.; Wilkinson, Thomas Lee
In: Sherman, Donald R., ed. Building structures: Proceedings of the sessions at Structures Congress '87 related to buildings; 1987 August 17-20; Orlando, FL. New York: American Soc. Civil Eng.; 1987: 205-220.

This paper evaluates results found in the literature to summarize what is known about bolted-connection design and what needs further research. By putting all this information in one place, the authors hope to help engineers and architects design safer timber buildings and structures.

33. Effect of Fire-Retardant Treatment and Redrying on the Mechanical Properties of Douglas-Fir and Aspen Plywood

Winandy, J. E.; LeVan S. L.; Schaffer, E. L.; Lee, P. W.
USDA Forest Serv. Res. Pap. FPL-RP-485; 1988. 20 p.

For many types of multifamily residential and nonresidential constructions, building codes require that softwood lumber and plywood be treated with fire-retardant (FR) chemicals. Although such treatment effectively retards combustion, it also reduces strength. Strength reduction can be magnified when the lumber or plywood is improperly treated and dried. To complicate matters, little is known about the effects of FR treatment and subsequent redrying on low-density hardwood species, now commonly used as core stock in commercial softwood-faced plywood. The primary objective of this study was to assess the effect of various FR treatments and redrying techniques on the drying time and degrade of FR-treated plywood. The secondary objective of this study was to determine the effects of various FR treatments and redrying regimes on the bending and horizontal rolling shear properties of two species of exterior-grade structural plywood. The effect of press drying on the strength properties of FR-treated plywood was also investigated.

34. Bending Performance of Spliced, Nailed-Laminated Posts

Winstorfer, S. G.; Moody, R. C.; Cramer, C. O.
Trans. ASAE 30(6): 1791-1796; 1987.

This study investigated the effect of three splice variables on post stiffness and bending strength. These variables—splice length, splice location, and the presence or absence of a reinforcing metal nail plate—were evaluated by comparing their relative effect on post stiffness and strength.

fire safety

35. Thermal Degradation Properties of Wood Reacted with Diethylchlorophosphate or Phenylphosphonic Dichloride as Potential Flame Retardants

Ellis, W. D.; Rowell, R. M.; LeVan, S. L.; Susott, R. A.
Wood Fiber Sci. 19(4): 439-445; 1987.

Improved thermal degradation properties (an indication of improved flame-retardant properties) were observed when Southern Pine was reacted with either diethylchlorophosphate (DECP) or phenylphosphonic dichloride (PPDC). These two compounds may prove useful as flame retardants for wood.

36. Fire Problems Associated With the Use of Hardwoods in Furnishings, Paneling, and Flooring

LeVan, Susan L.

In: Applying the latest research to hardwood problems: Proceedings of the 15th annual hardwood symposium of the Hardwood Research Council; 1987 May 10-12; Memphis, TN. Memphis, TN: Hardwood Research Council; 1987: 109-119.

The objective of this paper is to discuss flamespread, heat release, and the toxicity of the combustion products in connection with the use of hardwoods.

general

37. Quantitative Determination of Carbohydrates in Solution Via a Reduction/Permetylation Technique

Helm, Richard F.; Conner, Anthony H.; Young, Raymond A.

J. Carbohydrate Chem. 6(4): 569-586; 1987.

A reduction/permetylation technique has been developed for the quantitative gas chromatographic analysis of anhydrosugars, monosaccharides, and disaccharides. All derivatizations are carried out in the same vial, and transfers are not necessary until recovery of the permethylated derivatives. The reaction scheme is extremely simple and offers improved accuracy over standard gas chromatography carbohydrate analysis protocols. Emphasis is placed on quantitative compound recovery, and relative response factors are presented for several carbohydrates. The sodium hydroxide/methyl iodide permetylation reaction has also been shown to be a viable replacement for standard dimsyl anion procedures utilized for methylation analysis of polysaccharides. Application of the reduction/permetylation sequence to the analysis of the hydrolyzate resulting from the dilute sulfuric acid hydrolysis of cellulose demonstrates that reversion products account for a considerable amount of the glucose losses with levoglucosan, 1,6-anhydro- β -D-glucofuranose, isomaltose, and gentiobiose predominating.

38. Electric Moisture Meters for Wood

James, William L.

USDA Forest Serv., Gen. Tech. Rep. FPL-GTR-6; 1988. 17 p.

Two major classes of electric moisture meters are the conductance (resistance) type and the dielectric type. Conductance-type meters use penetrating electrodes that measure in a small volume, so moisture gradients may be deduced by repeated measurements at increasing depths. Dielectric-type meters use surface electrodes that do not puncture the wood surface and can measure the moisture content of relatively dry wood. This paper describes these major types of meters and includes detailed information on the kinds of electrodes used with each type.

New Ideas for Timber Bridges

Oliva, Michael G.; Tuomi, Roger L.; Dimakis, A. G. In: Trans. Res. Rec. 1053. Washington, DC: Transportation Research Board, National Research Council; 1986: 59-64.

Available from Information Services Division, Kurt F. Wendt Library, University of Wisconsin-Madison, 215 North Randall Avenue, Madison, WI 53706. Cost: \$5.00.

The fact that nearly half the bridges in the United States are listed as either functionally or structurally deficient lends impetus to search for new ideas for building and maintaining bridges. The Forest Service, U.S. Department of Agriculture, with a vast number of bridges under its care, is cooperating with the University of Wisconsin to

investigate new techniques for timber bridge design and construction. Described in this paper are promising new ideas that are being examined for construction, rehabilitation, and production of efficient performance and low cost in timber bridge systems.

39. Treatments That Enhance Physical Properties of Wood

Rowell, Roger M.; Konkol, Peggy

USDA Forest Serv. Gen. Tech. Rep. FPL-GTR-55; 1987. 12 p.

This report was prepared for anyone who wants to know more about enhancing physical properties of wood, from the amateur wood carver to the president of a forest products company. The authors describe chemical and physical treatments of wood that enhance the strength, stiffness, water repellency, and stability of wood. Treatment methods and properties and applications of treated wood are described in the text and summarized in a table. Though some of the chemical reactions described are complex, the language used to describe them is not. Several terms are defined in a glossary.

40. Kiln-Drying Time of Split Oak Firewood

Simpson, William T.; Boone, R. Sidney; Chern, Joseph

USDA Forest Serv. Res. Note FPL-RN-0254; 1987. 5 p.

This report gives results of drying split, undebarked, oak firewood kiln-dried at 140, 180, and 220 °F from 52 to 20 percent moisture content (dry basis) in 260, 90, and 30 hours. Pieces stacked parallel to the direction of airflow dried as quickly as pieces piled randomly.

41. A Mathematical Model for Indoor Humidity in Homes During Winter

Ten Wolde, Anton

In: Proceedings, symposium on air infiltration, ventilation, and moisture transfer; 1986 December 2-4; Fort Worth, TX. Washington, DC: Building Thermal Envelope Coordinating Council; 1988: 3-32.

This paper verifies a simple mathematical expression for indoor humidity as a function of moisture generation rate, ventilation, and storage parameters; it determines moisture generation rates and storage parameter values, and it determines the effect of ventilation controls on humidity and ventilation rate.

microbial and biochemical technology

42. Continuous Ethanol Production from D-Xylose by *Candida shehatae*

Alexander, M. A.; Chapman, T. W.; Jeffries, T. W. Biotechnol. Bioeng. 30: 685-691; 1987.

The objectives of this work were to determine the effects of important process variables such as aeration rate, D-xylose concentration, and ethanol concentration on the

fermentation rate and to obtain high volumetric ethanol production rates. Continuous methods were used because they allow collection of accurate rate data at constant environmental conditions. Such data facilitate the development of a kinetic model describing the effects of process variables. Of special interest was the fermentation performance at high volumetric production rates. High volumetric rates require high cell density, which is usually achieved using a cell immobilization or recycle technique.

43. Oxidation of Aromatic Pollutants by *Phanerochaete chrysosporium* Ligninase

Hammel, K. E.; Kalyanaraman, B.; Kirk, T. K.

In: Lignin enzymic and microbial degradation: Symposium international; 1987 April 23-24; Paris. Paris: Institut National De La Recherche Agronomique; 1987: 45-49.

The lignin peroxidase of *Phanerochaete chrysosporium* catalyzes the oxidation of various aromatic pollutants and compounds related to them. Polycyclic aromatic hydrocarbons with ionization potentials less than about 7.6 eV are oxidized to quinones, as are polychlorinated phenols that contain a chlorine at the 4 position. Certain dibenzo(*p*)dioxins are also oxidized by lignin peroxidase, and the intermediate dibenzo(*p*)dioxin cation radical is observable by visible and electron spin resonance spectrometry.

44. Horseradish Peroxidase Oxidizes 1,2,4,5-Tetramethoxybenzene by a Cation Radical Mechanism

Kersten, Ph.-J.; Kalyanaraman, B.; Hammel, K. E.; Kirk, T. K.

In: Lignin enzymic and microbial degradation: Symposium international; 1987 April 23-24; Paris. Paris: Institut National De La Recherche Agronomique; 1987: 75-79.

Recent studies show that ligninase oxidizes various non-phenolic substrates by one electron to give cation radical intermediates. To investigate the possibility that other peroxidases may have a similar mechanism, we tested various methoxybenzenes as substrates with horseradish peroxidase and hydrogen peroxide. We found that 1,2,4,5-tetramethoxybenzene is a good substrate. The corresponding cation radical intermediate was detected directly by ESR spectroscopy, and product analyses indicated that 2,5-dimethoxy-*p*-benzoquinone is a final product of the oxidation. Experiments with H₂¹⁸O showed that the quinone oxygens come from water. These results are discussed in relation to the oxidation potentials of peroxidases.

45. Involvement of a New Enzyme, Glyoxal Oxidase, in Extracellular H₂O₂ Production by *Phanerochaete chrysosporium*

Kersten, Ph.-J.; Kirk, T. K.

In: Lignin enzymic and microbial degradation: Symposium international; 1987 April 23-24; Paris. Paris:

Institut National De La Recherche Agronomique; 1987: 107-112.

The importance of extracellular hydrogen peroxide in lignin degradation has become increasingly apparent with the recent discovery of hydrogen peroxide-requiring ligninases produced by white-rot fungi. Here we describe a new hydrogen peroxide-producing activity of *Phanerochaete chrysosporium* that involves extracellular oxidases able to use simple aldehyde-, α -hydroxycarbonyl-, or α -dicarbonyl compounds as substrates. The activity is expressed during secondary metabolism, when the ligninases are also expressed. Two of the oxidase substrates, glyoxal and methylglyoxal, were also identified in the culture fluid as secondary metabolites.

46. Biochemistry of Lignin Degradation by *Phanerochaete chrysosporium*

Kirk, T. Kent

In: Aubert, J.-P.; Beguin, P.; Miller, J., eds. Biochemistry and genetics of cellulose degradation: Proceedings of the Federation of the Microbiological Societies symposium no. 43; 1987 September 7-9; Paris. San Diego, CA: Academic Press Inc.; 1988: 315-332.

Many diverse microbes, including anaerobic and aerobic bacteria and fungi, degrade cellulose. Most cellulose, however, is not accessible to the degradative enzymes until its coating of the natural plastic lignin is removed. Lignin can be removed chemically (as in pulping), physically (as in fine grinding by certain insects), or enzymatically. In this chapter the author discusses the current status of understanding the enzymatic degradation of lignin.

47. Enzymatic Combustion: The Degradation of Lignin by White-Rot Fungi

Kirk, T. K.

In: Lignin enzymic and microbial degradation: Symposium international; 1987 April 23-24; Paris. Paris: Institut National De La Recherche Agronomique; 1987: 51-56.

Degradation of the lignin polymer by white-rot fungi can be viewed as an "enzymatic combustion," producing a wide variety of intermediates. This paper treats some of the implications of this concept and raises a number of questions for further research.

48. Enzymatic "Combustion": The Microbial Degradation of Lignin

Kirk, T. Kent; Farrell, Roberta L.

Ann. Rev. Microbiol. 41: 465-505; 1987.

This paper encapsulates the major findings of lignin biodegradation research in the past 5 to 6 years, emphasizing the research that immediately preceded and followed the discovery in 1982 of the first lignin-degrading enzyme. That discovery projected the field into the realm of biochemistry and molecular biology and opened up new prospects for application.

49. Lignin Degradation by *Phanerochaete chrysosporium*

Kirk, T. Kent

ISI Atlas of Sci.: Biochem. 1(1): 71-76; 1988.

Since its discovery, ligninase has been studied extensively in a number of laboratories. It is a peroxidase and appears to play a major role in the initial depolymerization of lignin by *P. chrysosporium*. In 1984 a second peroxidase, termed manganese peroxidase, was also discovered in the extracellular broth of ligninolytic cultures of *P. chrysosporium*. Manganese peroxidase might have a role similar to that of ligninase, but its function is still being clarified. Both enzymes require extracellular hydrogen peroxide, meaning that the enzyme system supplying that cofactor is also a key component of the polymer-degrading system. Several H₂O₂-producing enzymes have been implicated. This paper discusses ligninase, Mn peroxidase, and H₂O₂-producing enzymes of *P. chrysosporium*.

50. Mass Spectrometric Method to Determine the Chain Length of Oligosaccharides Attached to Phenolic Polymers by Nonglycosidic Linkages

Minor, James L.; Pettersen, Roger C.

J. Agric. Food Chem. 35(6): 993-996; 1987.

In many plants, a portion of the polysaccharides appears to have a very low degree of cross-linking with aromatic polymers such as lignin or flavolans. The proportion of cross-linked units may be enriched for study by enzymatically hydrolyzing the nonbonded carbohydrates. This paper describes a convenient method for the simultaneous analysis of sugar content and apparent chain length of the oligosaccharide fragments remaining after enzymatic hydrolysis. The analysis assumes attachment to the phenolic polymers by nonglycosidic linkages. The hemiacetal ends of the oligosaccharide fragments are reduced with sodium borohydride while the fragments are still attached to the phenolic polymer. After acid hydrolysis, monomeric sugars are reduced with sodium borodeuteride. The mixed isotopic products are analyzed as their alditol acetate derivatives by capillary gas chromatography/mass spectrometry with selected ion monitoring. The isotopic ratioing procedure is detailed and the precision determined. The method is accurate to one monomeric unit for oligosaccharide chain lengths of less than 10.

51. Cellobiose: Quinone Oxidoreductase Does Not Prevent Oxidative Coupling of Phenols or Polymerisation of Lignin by Ligninase

Odier, E.; Mozuch, M.; Kalyanaraman, B.; Kirk, T. K.

In: Lignin enzymic and microbial degradation: Symposium international; 1987 April 23-24; Paris. Paris: Institut National De La Recherche Agronomique; 1987: 131-136.

In this study, the effect of CBQase on ligninase polymerisation of guaiacol and lignin was investigated, the formation of a phenoxy radical from a phenol by ligninase was studied, and the action of CBQase on radical stability is determined.

52. Assessment of 30 White Rot Basidiomycetes for Selective Lignin Degradation

Otjen, Lewis; Blanchette, Robert; Effland, Marilyn; Leatham, Gary
Holzforschung. 41(6): 343-349; 1987.

Thirty wood-inhabiting basidiomycetes were screened for their ability to selectively delignify wood. The amount of lignin and carbohydrates removed and the morphological and ultrastructural characteristics of the decayed wood were the major criteria used to determine fungi with superior lignin-degrading ability. *Phellinus pini*-2, *Pholiota mutabilis*, *Phlebia brevispora*-1, and *Phanerochaete chrysosporium* were the best delignifiers of both birch and pine. Different isolates of the same species of fungi differed in both the type of decay caused and their selectivity for lignin. Almost all fungi tested caused greater weight losses in birch blocks than in pine blocks. Most fungi isolated from gymnosperms caused greater weight losses in pine than did isolates from angiosperms. The fungi studied produced two different types of selective delignification. The first type resulted in extensive lignin removal from localized areas within wood blocks. The second type resulted in a more uniform loss throughout wood blocks but less extensive loss from individual cell walls.

53. The Role of Alcohol Dehydrogenase in the Fermentation of D-Xylose by *Candida shehatae* ATCC 22984

Prior, Bernard A.; Alexander, Michael A.; Yang, Vina; Jeffries, Thomas W.
Biotechnol. Letters 10(1): 37-42; 1988.

When the oxygen supply to an aerobic chemostat culture of *Candida shehatae* growing on D-xylose was reduced to oxygen-limited and anoxic conditions, accumulation of ethanol occurred, the specific activity of alcohol dehydrogenase (ADH) increased up to four-fold, and the number of ADH isozymes detected increased from one to three. ADH in crude extracts prepared from anoxically grown cells had a lower affinity for but was more tolerant to ethanol than in extracts prepared from aerobically grown cells. ADH activity appeared to be sufficient for ethanol production by *C. shehatae* under anoxic conditions.

54. Metabolism of Lignin Model Compounds of the Arylglycerol- β -Aryl Ether Type by *Pseudomonas acidovorans* D₃

Vicuna, R.; Gonzalez, B.; Mozuch, M. D.; Kirk, T. Kent

Appl. Environ. Microbiol. 53(11): 2605-2609; 1987.

A natural bacterial isolate that the authors have classified as *Pseudomonas acidovorans* grows on the lignin model compounds 1-(3,4-dimethoxyphenyl)-2-(2-methoxyphenoxy)propane-1,3-diol and 1-(4-hydroxy-3-methoxyphenyl)-2-(2-methoxyphenoxy)propane-1,3-diol, as well as on the corresponding 1-oxo compounds, as sole sources of carbon and energy. In a suggested degradation scheme, the key reaction is cleavage of the ether linkage between C-2 (C_β) of a phenylpropane moiety and 2-methoxyphenoxy moiety (β -aryl ether cleavage). On

the basis of compounds identified, cleavage appears formally to be reductive. Because this is unlikely, the initial cleavage products probably were not detected. The implications of these results for the enzyme or enzymes responsible are discussed.

mycology

55. Neotypification of *Sparassis crispa*

Burdsall, Harold H., Jr.; Miller, Orson K., Jr.
Mycotaxon. 31(2): 591-593; April-June 1988.

Fungal taxonomy and nomenclature are constantly plagued by the lack of type specimens for purportedly well-known species described by starting point or prestarting point authors. The genus *Sparassis* Fries is a case in point. According to Burdsall and Miller, it is composed of two species, *S. spathulata* Schw. and *S. crispa* Wülf.:Fr. A lectotype was recently designated for *S. spathulata* by Burdsall and Miller. However, no nomenclatural type exists for *S. crispa*, the generic-type species. Even though the concept of *S. crispa* is well understood, it is not possible to relate the presently used biosystematic characteristics of micromorphology, chemotaxonomy, and other taxonomic methods yet to be developed to the words and pictures that now serve as its nomenclatural type. The purpose of this study was to designate a tangible and appropriate specimen as neotype. This removes the final elements of doubt as to what the name *S. crispa* represents.

56. Type Studies and Nomenclatural Considerations in the Genus *Sparassis*

Burdsall, H. H., Jr.; Miller, O. K., Jr.
Mycotaxon. 31(1): 199-206; January-March 1988.

Type specimens and authentic specimens of eight putative species of *Sparassis* were examined. Two species are recognized; *S. crispa* and *S. spathulata*. Synonymy is proposed.

Incidence of Decay Fungi in Stumps of Two Thinned Western Larch Stands in Northeastern Oregon

Filip, Gregory M.; Parks, Catherine A.; Seidel, Kenneth W.; Lombard, Frances F.
USDA Forest Serv. Res. Note PNW-RN-468; 1987.
5 p.

Available from Pacific Northwest Research Station, 319 S.W. Pine Street, P.O. Box 3890, Portland, OR 97208. No charge.

Incidence of decay fungi was measured in stumps from two thinned western larch stands (9 and 15 years after thinning), one precommercially thinned and one commercially thinned, in northeastern Oregon. Ten species of decay fungi were positively identified from 180 stumps. Most of the decay in the stumps was caused by either *Fomitopsis pinicola* (Swartz ex Fr.) Karst. or *Trichaptum abietinum* (Dicks. ex Fr.) Ryv., which normally are saprophytic wood decomposers.

Properties of Cellulose Degraded by the Brown-Rot Fungus, *Postia placenta*

Highley, Terry L.; Ibach, Rebecca; Kirk, T. Kent
1988 April 24-29; Spain. Document IRG/WP/1350.
Stockholm, Sweden: The International Research Group on Wood Preservation. 1988. 9 p.

Available from IRG Secretariat, Drottning Kristinas väg 47 C, S-114 28 Stockholm, Sweden. No charge.

To gain further understanding of the nature of the cellulose depolymerizing agent or agents of brown-rot fungi, brown-rotted cellulose was chemically and physically characterized. Various culture conditions, such as low nitrogen and elevated oxygen levels, did not induce degradation of cellulose by *Postia placenta* in liquid cultures. Therefore, brown-rotted cellulose for analysis was prepared by a nonliquid method using a soil-block technique. Analysis of the molecular weight distribution of the degraded cellulose indicated a fairly tight distribution centered around DP 232. From x-ray diffraction analysis, it appears that there was a preferential attack on the smaller crystallites and amorphous regions of the cellulose by the fungus, confirming earlier work. Infrared spectroscopy and carboxyl determinations with methylene blue showed that carboxyl groups were present in the degraded cellulose. Uronic acids were not detected in acid hydrolysates of the brown-rotted cellulose, indicating that oxidation was not at C-6. However, several acids were separated and are currently being studied.

An Electron Spin Reasonance Study of Manganese Changes in Wood Decayed by the Brown-Rot Fungus, *Postia placenta*

Illman, B. L.; Meinholtz, D. C.; Highley, T. L.
1988 April 24-29; Spain. Document IRG/WP/1359.
Stockholm, Sweden: The International Research Group on Wood Preservation. 1988. 10 p.

Available from IRG Secretariat, Drottning Kristinas väg 47 C, S-114 28 Stockholm, Sweden. No charge.

Electron spin resonance (ESR) spectrometry was used to examine wood decay by the brown-rot fungus, *Postia placenta*. Wood slivers of Douglas-fir, white fir, redwood, sweetgum, and yellow-poplar were incubated for 4 weeks in custom-made quartz ESR tubes with or without *P. placenta*. In all wood species without fungus, a weak partially resolved signal (about g=2, presumably due to manganese) was detected. No manganese-like signal was found in aerial hyphae of the fungus. Wood slivers with fungus had a smooth, well-resolved manganese signal with a larger amplitude than wood without fungus, indicating a larger amount of paramagnetic manganese. The ratio of amplitudes for slivers with and without fungus increased with incubation time, reflecting an accumulation of paramagnetic manganese during decay. Because of the nature of this closed system without culture media, the accumulation of paramagnetic manganese is most likely due to the change of wood manganese by the fungus.

Generation of Hydroxyl Radical by the Brown-Rot Fungus, *Postia placenta*

Illman, B. L.; Meinholtz, D. C.; Highley, T. L.
1988 April 24-29; Spain. Document IRG/WP/1360.
Stockholm, Sweden: The International Research Group on Wood Preservation. 1988. 9 p.

Available from IRG Secretariat, Drottning Kristinas väg 47 C, S-114 28 Stockholm, Sweden. No charge.

In an electron spin resonance (ESR) survey of various liquid cultures and wood slivers innoculated with the brown-rot fungus, *Postia placenta*, the spin trap dimethyl-1-pyrroline N-oxide (DMPO) was used to detect the presence of the hydroxyl radical. The ESR spectra for the paramagnetic DMPO-hydroxyl radical adduct was observed in (1) nitrogen-limited, liquid cultures having 1.0 percent glucose or 0.1 percent cellobiose as the carbohydrate source and (2) fungal infected wood slivers of Douglas-fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*). The 4-line ESR signal had a 1:2:2:1 intensity ratio, 15 G line splitting, and a g factor of 2.003. The signal was stronger and more stable in wood slivers than in liquid cultures. The effect of free radical scavengers on the DMPO-hydroxyl adduct signal is currently being studied.

Nitrogen Fixation in Woody Residue of Northern Rocky Mountain Conifer Forests

Jurgensen, M. F.; Larsen, M. J.; Graham, R. T.; Harvey, A. E.
Can. J. For. Res. 17: 1283-1288; 1987.

Available from School of Forestry and Wood Products, Michigan Technological University, Houghton, MI 49913, U.S.A. No charge.

Nitrogen fixation rates, as estimated by the acetylene reduction technique, were determined for large woody residues on four old-growth conifer sites in western Montana and northern Idaho. Residue loadings ranged from <50 Mg ha⁻¹ on a warm, dry Douglas-fir site in Montana to >150 Mg ha⁻¹ on a highly productive, wet, cedar-hemlock site in northern Idaho. Lignin and carbohydrate analyses indicated that wood on these sites was being decayed primarily by brown-rot fungi. The application of the nitrogen fixation results from this study to the northern Rocky Mountain region indicated that the majority of stands in the Douglas-fir, subalpine fir, and cedar-hemlock cover types would have nitrogen gains <0.5 kg ha⁻¹ year⁻¹. However, in some areas where residue loadings are heavy, such as overmature stands on cool, moist sites or following harvesting, nitrogen gains could be much greater.

57. Studies in the Genus *Phellinus*.

I. The Identity of *Phellinus rickii* With Notes on its Facultative Synonyms

Larsen, Michael J.; Lombard, Frances F.
Mycologia. 80(1): 72-76; 1988.

This paper resolves any question concerning the possible synonymy of *Phellinus rickii* (Bres.) David et Rajchenb. with *P. rickii* Teix. and determines whether any of the

proposed facultative synonyms would be an appropriate binomial in *Phellinus* to replace that used by David and Rajchenberg.

The Effect of Tunicamycin on Production and Secretion of Extracellular Carbohydrate-Degrading Enzymes by *Postia placenta*

Micales, J. A.; Highley, T. L.
1988 April 24-29; Spain. Document IRG/WP/1342.
Stockholm, Sweden: The International Research Group on Wood Preservation. 1988. 12 p.

Available from IRG Secretariat, Drottning Kristinas väg 47 C, S-114 28 Stockholm, Sweden. No charge.

The extracellular carbohydrate-degrading enzymes of wood-decay fungi are usually heavily glycosylated and therefore stable under most denaturing conditions. It is unlikely that wood decay can be prevented by simply inactivating these enzymes. Tunicamycin, an antibiotic produced by *Streptomyces lysosuperificus*, prevents the glycosylation of glycoproteins and can interfere with the secretion of these enzymes. The effect of tunicamycin on the production of extracellular carbohydrate-degrading enzymes of *Postia placenta* was determined in liquid culture. Enzyme production was inhibited at concentrations of 2.5 to 5 µl; glycosidases were more sensitive than glycanases. Colony morphology was greatly altered at these concentrations, but dry weights decreased only 20 to 30 percent. The thermostabilities of xylanase and α-galactosidase, and the pH stability of xylanase, decreased when formed in the presence of low concentrations of tunicamycin. This suggests that the enzymes are produced in an active but nonglycosylated (or underglycosylated) form. The deglycosylation of glycoproteins may be a physiologically specific means of controlling wood-decay fungi.

Some Physiological Characteristics of a Nondegradative Strain of *Postia* (= *Porina*) *placenta*

Micales, J. A.; Highley, T. L.
1988 April 24-29; Spain. Document IRG/WP/1341.
Stockholm, Sweden: The International Research Group on Wood Preservation. 1988. 16 p.

Available from IRG Secretariat, Drottning Kristinas väg 47 C, S-114 28 Stockholm, Sweden. No charge.

The decay capacity of 14 strains of the brown-rot fungus *Postia* (= *Porina*) *placenta* was determined using soil-wood block tests. One isolate was identified as being unable to degrade wood and was determined to be monokaryotic. It retained the ability to produce extracellular carbohydrate-degrading enzymes, although regulation of certain enzymes was atypical under certain cultural conditions. It produced hydrogen peroxide and oxalic acid under a variety of carbon and nitrogen regimes and did not contain double-stranded RNA. It failed to produce large quantities of extracellular polysaccharides in culture. An understanding of the physiology of this isolate would further our knowledge of decay mechanisms leading to safer preservation protocols.

58. The Use of Senescent Cultures of *Postia placenta*, *Gloeophyllum saeparium*, and *Gloeophyllum trabeum* in the Study of Wood Decay

Micales, J. A.; Highley, T. L.

In: Current topics in forest research: emphasis on contributions by women scientists: Proceedings of a national symposium; 1986 November 4-6; Gainesville, FL. Gen. Tech. Rep. SE-46. Asheville, NC: U.S. Department of Agriculture, Forest Service: 71-81.

The objective of this study was to determine whether certain cultural characteristics and the production of extracellular carbohydrate-degrading enzymes are related to senescence, and thus required for wood decay.

59. The Action of Isolated Brown-Rot Cell-Free Culture Filtrate, H_2O_2 - Fe^{++} , and the Combination of Both on Wood

Murmanis, L.; Highley, T. L.; Palmer, J. G. .
Wood Sci. Technol. 22: 59-66; 1988.

The objective of this work was to observe the action on wood by (1) cell-free culture filtrate from the brown-rot fungus, *Postia placenta*, (2) the H_2O_2 - Fe^{++} system, and (3) the combined action of cell-free filtrate and H_2O_2 - Fe^{++} . The authors hope that the information obtained will elaborate on the mechanism of wood degradation by brown-rot fungi.

processing of wood products

60. Tensile and Compressive MOE of Flakeboards

Carll, Charles G.; Link, Carol L.
Forest Prod. J. 38(1): 8-14; 1988.

In this study, the authors compared the axial tensile modulus of elasticity of different layers with axial tensile or compressive modulus of elasticity of full-thickness specimens, something that had not been done before. A specific objective of this study was to develop multiple regression equations of axial modulus of elasticity versus specimen specific gravity and flake alignment.

61. Live-Sawing Log-Grade Red Oak Logs

Cassens, Daniel; Maeglin, Robert R.
Forest Prod. J. 37(10): 49-53; 1987.

This paper discusses grade-sawing, live-sawing, and modified sawing that produces a cant to determine which method produces the most value. In this study, 66 low-grade red and black oak logs were divided into three groups and processed by each of the three methods. The boards were graded for maximum volume and value before and after edging. Grading for maximum value after edging showed that live-sawing produced more value than did cant-sawing, and cant-sawing more than grade-sawing. Live-sawing produced more value per unit time than did cant-sawing, and cant-sawing more than grade-sawing.

62. Flake Classification by Image Analysis

Geimer, Robert L.; Link, Carol L.

USDA Forest Serv. Res. Pap. FPL-RP-486; 1988.
25 p.

Image analysis is a technique that can be adapted to classify flakes by their geometric dimensions. This system is well suited to the flakeboard industry where flake dimensions, slenderness ratios, and aspect ratios are critical to the design and fabrication of structural material. This report develops basic relationships between image analysis and the more familiar screen fractionation. Analytical methods of presenting the data are discussed, and a cursory look is taken at correlating flake classification data to ultimate board performances.

63. Markets for Hardwood Laminated-Veneer-Lumber

Hoover, William L.; Eckelman, Carl A.; Ringe, James M.; Youngquist, John A.
Forest Prod. J. 37(10): 57-62; 1987.

Ever-increasing hardwood lumber costs and the continuing consumer preference for solid wood furniture construction has led to the use of a broad range of lumber substitutes. A substitute material with the potential for increased use is hardwood laminated-veneer-lumber (LVL). The purpose of this paper is to discuss possible applications of LVL in the furniture industry and to identify the cost criteria that would influence its adoption.

64. Juvenile Wood, Tension Wood, and Growth Stress Effects on Processing Hardwoods

Maeglin, Robert R.

In: Applying the latest research to hardwood problems: Proceedings of the 15th annual hardwood symposium of the Hardwood Research Council; 1987 May 10-12; Memphis, TN. Memphis, TN: Hardwood Research Council; 1987: 100-108.

The high-grade, large-diameter trees used for lumber and veneer no longer exist, and the average diameter of the hardwood timber resource continues to decline. Using smaller trees with a lower age results in trees with a higher proportion of juvenile wood, tension wood, and growth stress. This paper discusses the problems and alternative solutions of handling core wood in these hardwoods.

65. Alternative Methods for Sawing and Drying Structural Lumber From Second-Growth Loblolly Pine (*Pinus taeda*)

Maeglin, Robert R.; Simpson, William T.

In: Proceedings of the 6th Reunion sobre investigacion y desarrollo en productos forestales; 1987 November 25-27; Concepcion, Chile. Concepcion, Chile: Universidad del Bío-Bío; 1987. 12 p.

The processing of second-growth pine is a major problem. The combination of juvenile wood, compression wood, and growth stresses makes the manufacture of straight lumber difficult. Several studies at the Forest Products

Laboratory have shown that it is possible to minimize the warping of second-growth loblolly pine (*Pinus taeda*) lumber by modifying manufacturing techniques. Two of the most promising methods, Saw-Dry-Rip (SDR) and press drying, are reported in this paper.

66. Bacterial Infection of Oak—An Update

Ward, James C.; Schink, Bernard

In: Applying the latest research to hardwood problems: Proceedings of the 15th annual hardwood symposium of the Hardwood Research Council; 1987 May 10-12; Memphis, TN. Memphis, TN: Hardwood Research Council; 1987: 87-91.

The entire proceedings is available from the Hardwood Research Council, P.O. Box 34518, Memphis, TN 38184-0518. Cost: \$10.00.

Since 1983 there has been a sharp increase in the number of processing problems with oak lumber that is bacterially infected. This paper describes the nature of bacterial oak infection and its effect on the drying process, the ecological factors that are associated with bacterial oak infection, and the characteristics of bacterially infected trees.

pulp, paper, and packaging

67. The Compressive Load–Strain Curve of Paperboard: Rate of Load and Humidity Effects

Gunderson, D. E.; Considine, J. M.; Scott, C. T. *J. Pulp and Paper Sci.* 14(2): J37-J41; March 1988.

This paper reports the effect of load rate and humidity on edgewise compression properties of paperboard. One linerboard and one corrugating medium were tested at three load rates; 263 N/m/s, 2.63 N/m/s, and 0.0263 N/m/s, under constant 50 percent and 90 percent relative humidity (RH). Both paperboards exhibited lower compressive strength, lower initial stiffness, and higher failure strains as load rate was reduced. Compressive strength and initial stiffness were found to vary with the logarithm of load rate. The results also show that the paperboards in this study were more affected by load rate at 90 percent RH than at 50 percent RH. The hyperbolic tangent model is extended to determine load as a function of strain and load rate. In this model, comparison of the machine direction and the cross-machine direction response shows that the cross-machine direction is more sensitive to load rate at 50 percent RH, but that the machine direction is more sensitive at 90 percent RH.

68. Press Drying: A Way to Use Hardwood CTMP for High-Strength Paperboard

Horn, Richard A.; Bormett, David W.; Setterholm, Vance C.

Tappi J. 71(3): 143-146; 1988.

Chemithermomechanical pulp (CTMP) is not presently used in linerboard or corrugating medium. Because of its high lignin content and stiff fibers, CTMP dried conventionally cannot achieve sufficient bonding for products

requiring high strength. Results show that press-drying technology offers potential for using high-yield CTMP made from hardwoods for the manufacture of high-strength paperboard products. This paper reports that with the exception of tear strength, strength properties of press-dried CTMP paperboards were equivalent to or better than those of commercial paperboards. In particular, compressive strength of the CTMP paperboards was much higher. Combined board and containers made from press-dried CTMP paperboards met current expectations except in impact resistance. At high humidity, high retention of short-column strength in the combined board and of top-to-bottom compressive strength in the containers was noted.

69. Disk Separation: Fiber Recovery From Recycled Newsprint Papermill Tailings

Klungness, John H.

In: Proceedings, TAPPI 1987 pulping conference; 1987 November 1-5; Washington, DC. Atlanta, GA: TAPPI Press; 1987: 729-734.

No single satisfactory industrial process exists for recovering fiber from wastepaper recycling mill tailing streams. This study was undertaken to determine the feasibility of using disk separation to recover recyclable fiber from a recycled newsprint mill screening system tailing stream. A secondary objective was to clean the fiber recovered from the tailings sufficiently to permit it to be fed forward to the papermill system.

70. Fungal Pretreatment of Aspen Chips Improves Strength of Refiner Mechanical Pulp

Myers, Gary C.; Leatham, Gary F.; Wegner, Theodore H.

Tappi J. 71(5): 105-108; 1988.

Pretreatment of wood chips with lignin-degrading fungi can improve the strength properties of unbleached refiner mechanical pulps. The effects of two white-rot fungi (*Phanerochaete chrysosporium* and *Dichomitus squalens*) prior to refiner mechanical pulping were studied. Strength and optical properties were compared in handsheets prepared from mechanical pulp of treated and untreated wood chips. Both fungal pretreatments resulted in handsheet strength properties better than those of the control when compared at an equivalent freeness. Fungal pretreatments decreased brightness and light-scattering coefficients but did not adversely affect opacity. Brightness of fungus-pretreated pulps was restored to that of the control by hydrogen peroxide bleaching. Lignin content of the chips was reduced by the fungal pretreatments.

71. The Detection of Xylan in Pulp Fibers by Energy-Dispersive Analysis and Scanning Electron Microscopy

Sachs, Irving

Microscope. 36(1): 1-10; 1988.

Energy-dispersive analysis (EDA), in combination with a scanning electron microscope, was used to detect iron-tagged carboxyl groups (esterified and acidic) of xylan in pulp fibers. Cellulose and lignin did not show the presence of iron when tested, and thus should not interfere

with the detection of iron-tagged xylan. The iron-tagging technique was used to monitor xylan in a softwood (spruce) and a hardwood (oak) before and after kraft pulping. Microscopical detection of xylan should lead to new approaches for improving paper strength.

structural fiber and particle products

72. Chemical Modification of Wood Substance

Rowell, Roger M.

In: Proceedings, Wood technology, chemistry and construction symposium; 1986 October 1-2; Stockholm, Sweden. Stockholm: Royal Swedish Academy of Engineering Sciences, Swedish Institute for Wood Technology Research, The Swedish Council for Building Research and The National Board for Technical Development; 1986. 9 p.

This paper discusses the chemical modification of solid wood and the reactions of chemical modification on reconstituted wood products. It describes a new wood acetylation procedure where Southern Pine and aspen flakes are acetylated with acetic anhydride alone without cosolvent or catalyst by a simple dip procedure. This procedure greatly shortens reaction time and simplifies chemical recovery. The paper also focuses on the international interest in additional research before commercialization of chemically modified reconstituted products is realized.

73. Acetylation of Bamboo Fiber

Rowell, Roger M.; Norimoto, Misato

J. Japan Wood Res. Soc. 33(11): 907-910; 1987.

The purpose of this research was to determine if bamboo fiber could be acetylated by a fast, simple acetylation procedure and to determine moisture sorption properties of acetylated bamboo fiber. Reactivity and moisture sorption of bamboo fiber are compared to aspen and pine wood flakes.

74. Tensile Strength and Toughness of Acetylated Pine and Lime Flakes

Rowell, Roger M.; Banks, W. Bart

British Polym. J. 19(5): 479-482; 1987.

The objective of this study was to acetylate very thin strips of pine (*Pinus sylvestris*) and lime (*Tilia vulgaris*) to various levels of acetyl weight gain and to determine the tensile strength and work-to-failure of the acetylated products.

timber requirements and economics

75. Future Forest Product Technology: A Key Determinant of Economic Benefits We Obtain From Forests

Ince, Peter J.

In: Economic and social development: A role for forests and forestry professionals: Proceedings of the

1987 Society of American Foresters national convention; 1987 October 18-21; Minneapolis, MN. Bethesda, MD: Society of American Foresters; 1988: 300-304.

Trends in forest product technology affect benefits we obtain from forests in the United States. This paper discusses current views on trends in forest product technology and the relationship of technological development to economic and social development.

76. Modeling Technological Change in Wood Products Processing

Ince, Peter J.; Skog, Kenneth E.; Spelter, Henry; Durbak, Irene A.; Howard, James L.

In: Cardellichio, Peter A.; Adams, Darius M.; Haynes, Richard W., eds. Forest sector and trade models: theory and applications: Proceedings of an international symposium; 1987 November 3-4; Seattle, WA. Seattle, WA: Center for International Trade in Forest Products, University of Washington; 1988: 257-265. Current and future technological developments in U.S. wood products processing were identified through a comprehensive literature review and through consultation with scientists, engineers, and managers in wood products research and industry. Potential future wood input requirements and manufacturing costs were then estimated, using process material flow models and engineering cost models. Estimated future wood requirements and manufacturing costs were incorporated into regional market models of major wood product sectors. These models were then used to project actual adoption of new technology in response to market conditions for timber and wood products. This paper reports the results of an economic model of technological change in wood products processing and its impact on timber production, consumption, and prices in the United States over the next 50 years.

77. Considerations in the Development of a Trade Model for the Pulp and Paper Sector

Lange, William J.; Ince, Peter J.; Durbak, Irene A.; Howard, James L.

In: Cardellichio, Peter A.; Adams, Darius M.; Haynes, Richard W., eds. Forest sector and trade models: theory and applications: Proceedings of an international symposium; 1987 November 3-4; Seattle, WA. Seattle, WA: Center for International Trade in Forest Products, University of Washington; 1988: 167-173.

This paper discusses the attributes of a pulp and paper model capable of serving as a simultaneously functioning component in the Timber Assessment Market Model (TAMM) system. These attributes include model structure, regional and product aggregation, final product demand, processing technology, and resource supply. The model is capable of projecting total wood fiber consumption for eight Forest Service timber supply regions 50 years into the future.

North American Industrial Markets: Current Wood Use and Trends

Luppold, William G.; McKeever, David B.

In: Hamel, Margaret P., ed. North American

wood/fiber supplies and markets: Strategies for managing change: Proceedings 47351; 1986 October 2-4; Chicago, IL. Madison, WI: Forest Products Research Society; 1987: 125-130.

Available from Northeastern Forest Experiment Station, 370 Reed Road, Broomall, PA 19008. No charge.

This paper presents the authors' estimates of hardwood and softwood lumber, hardwood and softwood plywood and veneer, and reconstituted panel consumption for furniture, wooden pallets and skids, railroad crossties, wooden boxes and crates, dunnage, blocking and bracing, and other miscellaneous end uses. Trends in consumption over the past 20 years are also examined. These trends are based primarily on reports from the U.S. Department of Commerce, Bureau of the Census, and Census of Manufactures. Recent Forest Service reports and information from industry and trade associations are also used.

78. Approaches to Modeling the Regional Demand for Timber Products for Housing in the United States

Marcin, Thomas C.

In: Dress, Peter E.; Field, Richards C., eds. The 1985 symposium on systems analysis in forest resources: Proceedings of Society of American Foresters symposium; 1985 December 9-11; Athens, GA. Athens, GA: Georgia Center for Continuing Education; 1987: 175-186.

Housing demand and timber products usage vary widely by region in the United States. Regional estimates of timber products demand are important elements of timber products marketing and forest resource planning. This paper describes a computer simulation model to estimate and project regional timber products demand for new housing in the United States.

79. Regional Variations in Housing Characteristics and Wood Products Consumption for Residential Construction in the United States

Marcin, Thomas C.

In: Busby, Rodney L.; De Steiguer, J. Edward; Kurtz, William B., eds. The blue and the gray: Proceedings of the 1987 joint meeting of the southern forest economists; 1987 April 8-10; Asheville, NC. Raleigh, NC: North Carolina State University; 1987: 145-154.

This paper presents a summary of regional differences in housing characteristics, such as the type and number of units constructed, their size, type of foundation, and the kinds and amounts of wood used. Overall estimates of consumption are presented for lumber and panel products by region.

80. Regional Pallet Production in the United States, 1985

McCurdy, Dwight R.; Ewers, James T.; Burde, John H., III; Kung, Fan H.; McKeever, David B.

In: Busby, Rodney L.; De Steiguer, J. Edward; Kurtz, William B., eds. The blue and the gray: Proceedings of the 1987 joint meeting of the southern forest economists; 1987 April 8-10; Asheville, NC. Raleigh, NC: North Carolina State University; 1987: 135-144.

This paper summarizes the results of two studies on the U.S. pallet industry conducted in 1985 by the Department of Forestry, Southern Illinois University at Carbondale. The first study looked at the volume and species of lumber used in pallet production. The second study investigated characteristics of the 2,340 known firms manufacturing pallets in 1985.

81. A Study of Lumber Use in Pallets Manufactured in the United States: 1982 and 1985

McCurdy, Dwight R.; Ewers, James T.; Kung, Fan H.; McKeever, David B.
Forest Prod. J. 38(2): 11-15; 1988.

National studies to determine the volume and type of lumber contained in pallets were conducted in 1982 and 1985. The 1982 study objective was to establish whether the "best guess" estimates of the past were still correct. The refined followup study of 1985 was conducted to validate the 1982 data and to note if any trends could be observed. The data were analyzed both on national and regional levels. The 1985 data are presented, with selected comparisons to the 1982 data.

82. Impact of Changing Solid Wood Products Technology on Timber Values

Spelter, Henry

In: Economic and social development: A role for forests and forestry professionals: Proceedings of the 1987 Society of American Foresters national convention; 1987 October 18-21; Minneapolis, MN. Bethesda, MD: Society of American Foresters; 1988: 297-299.

This paper looks at how technology developments in solid wood products manufacturing are enabling mills to economically process smaller logs. Species once considered to have little commercial value are now commonly used by mills for the manufacture of structural panels. Logs once considered suitable only for pulping are now being processed into plywood. Technological advances are redefining the concept of peelable and sawable timber. With size becoming a less important criterion, older and bigger categories of timber appear to be losing some of their value premiums over smaller logs. Strategies for future timber management should consider the probable narrowing of price differentials between large and small logs.

83. A Simplified Two-Variable Formula for Projecting U.S. Monthly Housing Starts

Spelter, Henry

Forest Prod. J. 38(1): 17-20; 1988.

This note describes a two-variable formula that projects, by month, single- and multifamily housing starts in the United States. It is based on a more complex formulation found in a widely used econometric model of the U.S.

economy. The simpler formulation yielded results almost as accurate as the more complex version for single-family housing starts, but was somewhat less accurate for multifamily starts. The formula may be useful to softwood lumber and panel manufacturers for shortrun projections of U.S. housing starts.

tropical wood utilization

84. Forest Products Technology Affects Tropical Forest Requirements

Laundrie, James F.; Montrey, Henry M.

In: Colon, Julio C. Figueroa, ed. Management of the forests of tropical America: prospects and technologies: Proceedings of a conference; 1986 September 22-27; San Juan, PR. Rio Piedras, PR: U.S. Department of Agriculture, Forest Service, Institute of Tropical Forestry; 1987: 437-448.

Five new technologies, developed or studied by the USDA Forest Service, Forest Products Laboratory, were selected and used to illustrate how they might affect the utilization of the present tropical forest resource and place new requirements on future tropical forest resources. The five new technologies were (1) utilization of mixed tropical hardwoods for various reconstituted products; (2) the press-dry papermaking process using high-yield unrefined hardwood pulps; (3) the saw-dry-rip process for producing structural lumber from hardwoods; (4) efficient and low-cost solar-wood energy kilns for drying lumber; and (5) the truss-framed building system for lower cost housing.

wood bonding systems

85. Bondability of Wood Surfaces

Johns, William E.; Myers, Gary C.; Motter, William K.

In: Maloney, Thomas M., ed. Proceedings, 21st International particleboard/composite materials symposium; 1987 March 24-26; Pullman, WA. Pullman, WA: Washington State University; 1987: 253-278.

Previous work in wood chemistry and adhesive bonding has shown that chemical factors of wood such as pH or total acids can act reliably as predictors for internal bond and shear strength. This research was undertaken to determine if it was possible to chemically alter the nature of wood to enhance the effectiveness of adhesive.

86. Evaluation of Flakeboard Bonded With Xylitol-Modified Alkaline Phenolic Resin

Jokerst, Ronald W.; Conner, Anthony H.
Forest Prod. J. 38(2): 45-48; 1988.

The objective of this research was to develop new adhesive systems in which all or part of the petroleum-derived components are replaced by readily available, renewable material without sacrificing high durability or ease of bonding. The work reported here is an evaluation of the potential of xylitol-modified phenolic resin for bonding Douglas-fir flakeboard.

special items

Dry Kiln Schedules for Commercial Woods—Temperate and Tropical

Boone, R. Sidney; Kozlik, Charles J.; Bois, Paul J.; Wengert, Eugene
FPL Gen. Tech. Rep. 57; 1988. 158 p.

Dry Kiln Schedules for Commercial Woods provides hundreds of dry kiln schedules for temperate and tropical woods. Primarily for use by dry kiln operators and others interested in dry-kilning wood, the report consolidates and updates drying schedules from many sources, making them easy to find and convenient to use.

Included are dry kiln schedules for several thicknesses of over 500 temperate and tropical woods with special schedules for wooden squares, handle stocks, and gun stock blanks. The consolidated information comes from the world literature, with major emphasis on U.S., Canadian, and British publications.

In some cases, revised schedules are suggested that update the U.S. Department of Agriculture Handbook No. 188, *Dry Kiln Operator's Manual*. These changes occur mostly for western U.S. and Canadian softwoods and U.S. Southern Pine. The report also includes the latest suggested high-temperature (exceeding 212 °F) drying schedules for both softwoods and hardwoods. Each schedule is entirely written out for completeness and for easy use.

Experienced kiln operators may use the report as a general guideline, altering the schedules according to individual kiln conditions and wood property variations. Most dry kiln schedules in the report were intended for use with steam-heated kilns with temperature and humidity closely controlled. This publication groups commercial woods according to their geographical origins, United States and Canada, Mexico, Central and South America, Asia and Oceania, Africa, and Europe. Species are listed alphabetically according to their common name in the Index of Schedules for U.S. and Canadian sections. For easy cross reference, a common name-botanical name list is included in the index.



FPL scientist Sidney Boone adjusts control instrument to new set points for the drying schedule.

Single copies of FPL General Technical Report 57, Dry Kiln Schedules for Commercial Woods—Temperate and Tropical, are available by writing the Forest Products Laboratory, One Gifford Pinchot Dr., Madison, WI 53705-2398.

Wood Finishing

Cassens, Daniel L.; Feist, William C.

Sponsored by the Cooperative Extension Services of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin, and Lincoln University-Missouri.

Finishing Exterior Plywood, Hardboard and Particleboard

North Central Regional Extension Publication #132 (1988), 6 p.

Paint Failure Problems and Their Cure

North Central Regional Extension Publication #133 (1988), 6 p.

Discoloration of House Paint—Causes and Cures

North Central Regional Extension Publication #134 (1988), 6 p.

Selection and Application of Exterior Finishes for Wood

North Central Regional Extension Publication #135 (1988), 8 p.

Finishing and Maintaining Wood Floors

North Central Regional Extension Publication #136 (1988), 8 p.

These illustrated bulletins are designed to answer commonly asked questions about various aspects of wood finishing. Written for farm and homeowners, builders, painters, and other wood users, they describe proper finishing techniques and the causes, prevention, and cures of wood-finishing problems. *Finishing Exterior Plywood, Hardboard and Particleboard* gives tips for preconstruction care such as preparation of these materials and instructions for finishing and refinishing. *Paint Failure Problems and Their Cure* describes moisture, blistering, peeling, and cracking problems and their prevention and cure. It also covers repainting procedures.

Discoloration of House Paint—Causes and Cures discusses mildew, water-soluble extractives, blue stain, iron stain, chalking, and brown stain over knots. *Selection and Application of Exterior Finishes for Wood* discusses how to select the appropriate finish for the many different types of wood products currently used on structures. It also covers correct application procedures.

Finishing and Maintaining Wood Floors describes wood properties, various types of finishes, preparation of both old and new surfaces, and finish application techniques. Protecting and repairing the finish are also covered.

Distributed in cooperation with the U.S. Department of Agriculture Extension Service, these bulletins update publications originally issued in 1981. Authors of this revision are Daniel L. Cassens, Department of Forestry and Natural Resources, Purdue University, and William C. Feist, Forest Products Laboratory, USDA Forest Service.

Copies of these publications are available from Purdue University, Agricultural Communication Service, Media Distribution Center, 301 S. Second Street, Lafayette, IN 47905-1092. Cost: \$.50 per copy. Requests should include complete publication name and number.

A complimentary copy may be obtained for publications in the list that are preceded by a number:

- 1) Circle the appropriate number(s) below.
- 2) Make any necessary address corrections on mailing label on back cover. (Do not remove label. It is used for mailing your publication.)
- 3) Remove this page, fold and tape as indicated, and mail using first-class postage.

Note: Supplies of these publications are limited. If you no longer wish to receive this publication, please indicate below:

Please delete my name from your mailing list.

1. Fold.

2. Fold.

1	2	3	4	5	6	7	8
9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24
25	26	27	28	29	30	31	32
33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56
57	58	59	60	61	62	63	64
65	66	67	68	69	70	71	72
73	74	75	76	77	78	79	80
81	82	83	84	85	86		

First Class Postage

Information Services
U.S. Department of Agriculture
Forest Service
Forest Products Laboratory
One Gifford Pinchot Drive
Madison, WI 53705-2398
USA



1022966833

U.S. Department of Agriculture

Forest Service

Forest Products Laboratory

One Gifford Pinchot Drive

Madison, Wisconsin 53705-2398

Official Business

Penalty for Private Use \$300

Address Correction Requested

DO NOT REMOVE LABEL

Technical Library, Room 305
Pacific Southwest Forest &
Research Experiment Station
Box 245, 1960 Addison Street
Berkeley CA 94701

88/1

Bulk Rate
Postage & Fees Paid
USDA-FS
Permit No. G-40